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ABSTRACT

This booklet about computers considers time, space, and spirit. Time refers to a sense of history; space refers to geography; and spirit referes to life and thought. Several chapters on the history and concepts of computers, a time line related to the concepts, a map of the important geography related to these concepts, a glossary of important terms, and a list of several study suggestions. (CW)

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The Computer

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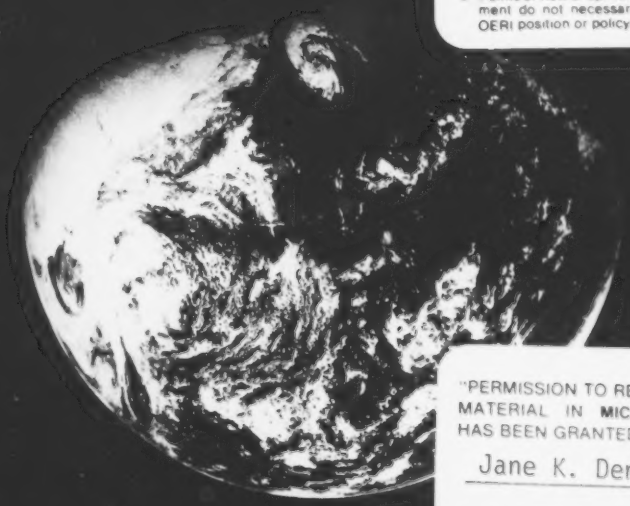

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A HAWKHILL LEARNING POWER BOOK

2

TIME, SPACE AND SPIRIT

KEYS TO SCIENTIFIC LITERACY

To the student,

This short book will help you understand our modern world. It has changed a lot since your parents were born. Even more since you were born. And it will change still more–much more–in your lifetime.

What is behind most of these big changes? Two things. Science and technology.

What can you do about it? The first step is to understand more about science and technology and how they connect with our world. Especially the ever-growing world of free democratic societies. One way to do this–the way this book follows–is to look at the world from three angles: *Time, Space* and *Spirit*.

Time means history. You can learn how science and technology have worked in the past and are working today.

Space means geography. You can learn where important things happened in the past and are happening today.

Spirit means life. The life of the mind. You can learn the key words, concepts and ideas that power science and technology (and society) today.

This book teaches about science, technology and society from all three of these angles–*Time, Space* and *Spirit*.

Read on.

This book belongs to:

The Computer

Bill Stonebarger
Illustrations by Lin Haley

Hawkhill Associates
Madison, Wisconsin

This book is one of a series of sixteen Learning Power Books in the *Time, Space and Spirit–Keys to Scientific Literacy* series. It is designed to accompany the video program of the same name.

The *Time, Space and Spirit–Keys to Scientific Literacy* series was written and produced with consultation from the History of Science Department at the University of Wisconsin-Madison.

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most important battle of WW II

The most important battle of World War II was fought at a rambling English country house called Bletchley Park, in a green suburb just north of London. At least that is the opinion of some historians. Inside a modest house and in a small shed-like building on the other side of a pond, a small group of scholars, mathematicians and scientists worked overtime in top-secret to break the German war codes.

world's first electronic computer

With the help of a strange looking machine called Colossus I, the world's first electronic computer, they succeeded.

Alan Turing

One of the leaders of the group was Alan Turing, then only thirty-one years old. Turing was only a middling scholar at Cambridge University. He liked running, rowing and playing the violin better than attending classes. He was also fascinated by gadgets and by mathematical and logical puz-

zles. And, most of all, by the possibility of building a machine that would be intelligent.

an impossible dream

Turing was sidetracked from his main goal by the war-related computer work. Unfortunately he did not live long enough to see the transistors, microchips and the electronic wizardry that might provide the hardware to make his artificial intelligence a real possibility.

became reality

Turing and others of his day had the dream and the direction. Today much of that dream is a reality. We have not yet made a true artificial intelligence. But we have created a reality that is fast transforming our modern world. That reality is the modern computer.

an abacus

Alan Turing was not the first man to design a computer, nor to dream of artificial intelligence. A simple machine called an *abacus* was probably one of the first computers. It was invented thousands of years ago in China.

The abacus is not, of course, a real computer in our sense. It's not even a calculator, since a human must do all the actual operations. However, the inventors of the abacus did take the first step toward calculators and computers. That is, they turned abstract numbers into physical things.

a way to keep track

In the case of the abacus, the physical things are beads strung along rods. By moving the beads along the rods, people had a way to calculate; a way to keep track; a way to remember. It was easy

to put more numbers in and easy to read what came out–an answer to numerical calculations.

five parts of all computers

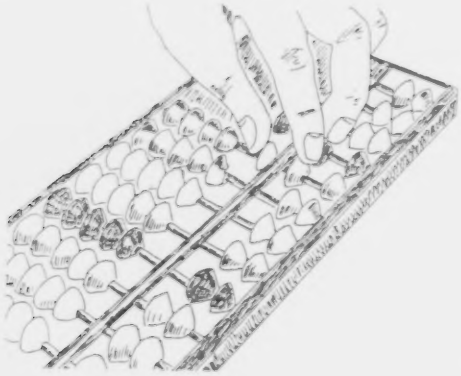
There you have in outline the five basic parts of the most sophisticated modern computer. (1) A way to put numbers in (or letters or sounds or whatever). (2) A number cruncher (the part of the machine that actually counts). (3) A control unit (the part that makes sure everything happens in the right order). (4) A memory. (5) An output (a way to show and tell the answers).

how an abacus works

In the abacus, of course, the actual input, calculation, control, memory and output all involve the human brain, powered by the human body and manipulated by the human hand. But the beads and rods do help. They help the brain remember, make it easier for the brain and fingers to control and calculate, and provide a convenient way to put numbers in and take out the answers.

faster than a calculator

The abacus is such a help, as a matter of fact, that in a famous calculating competition after World War II a Japanese clerk using only his abacus defeated a U.S. Army clerk using the best available mechanical desk calculator.



abstract numbers in a physical way

Keep those five essential parts of the computer in mind as we trace the roundabout paths humans have taken to get from an abacus to a modern computer. And if five is too many to keep in mind (as it is, the human mind, you see, is limited), at least remember one thing.

To make a computer you have to have some way to represent abstract numbers in a physical way. As we will see, that physical way can be as varied as the human imagination and ingenuity can devise.

ways of making numbers physical

Examples of ways to represent abstract numbers in physical ways are: fingers and toes; scratches on a stone; beads on a rod; a gear wheel in a particular position; an electromagnetic relay opened or closed; a switch on or off; an electric pulse in a vacuum tube; an electrical pulse in a transistor; a piece of metal magnetized or not; a bubble here or there.

The order used in listing the above physical ways is approximately the same order followed by the ingenious humans who invented the many varieties of the modern computer.

Pascal and the *Pascaline*

Take gears first. The first calculator using gears was made about three hundred years ago in France. It was invented by a famous French philosopher and mathematician, Blaise Pascal. He was inspired to invent it, it is said, by sympathy for his father. Pascal's father, you see, was a tax collector who often had to stay up half the night doing laborious calculations by hand.

first mechanical calculator

With Pascal's *Pascaline*, which he invented when he was only nineteen, you could dial in numbers on wheels, and the gears inside the box would do the rest. The answer was displayed immediately in little windows at the top of the box. The *Pascaline* calculator could add or subtract and, like modern calculators, by repeated addition and subtraction, it could also multiply and divide.

hoped to make a fortune

Pascal and his father hoped to make a fortune manufacturing and selling the *Pascaline* but it never happened. Hiring clerks to do the calculating was a cheaper way for seventeenth century French businessmen. And they were not particularly interested in making the clerks' work easier.

Other men invented gear calculators after Pascal, but the next major step forward was not taken for another two hundred years.

Charles Babbage and Ada Lovelace

An English gentleman named Charles Babbage designed the world's first true computer in the middle of the nineteenth century. He called it the *Analytical Machine*. An English lady, Ada Lovelace,

daughter of the poet Lord Byron, produced the world's first computer program to operate the *Analytical Machine.*

a steam engine for power

The truth is, they never quite finished their machine. It was at least a hundred years before its time. Current electricity had not been invented so Babbage was restricted to using physical wheels and cogs to represent numbers in his computer. And to power the machine he had to rely on a steam engine!

machine a failure

He constructed models, but the complications of so many rods and wheels and ratchets and gears and the tolerances needed were too great for the technology of his day. Though he devoted most of his life and personal fortune to the effort, it remained a practical failure.

His programmer, Ada Lovelace, actually hoped to use the analytical machine to pick winners at the race track. This didn't work out either.

Babbage's *Analytical Machine* may have been a practical failure, but it had all the ingredients of a true computer rather than just a mechanical calculator like Pascal's *Pascaline.*

input device of punched cards

One–it had an input device. Babbage used stiff cards with holes punched in a particular pattern. He got the idea for this input device from an innovative French weaver named Joseph Jacquard. Jacquard invented a system that used a belt of cards with holes in them to make a desired pattern in woven cloth. His invention of 1801 was called a Jacquard loom, and in principle is still used today in modern weaving looms.

a number cruncher

Two–it had an arithmetic unit. Truly a number cruncher! It was called the "mill" and was a maze of wheels, rods, ratchets and gears.

control unit

Three–it had a control unit that could be programmed to tell the machine what to do, and in what sequence.

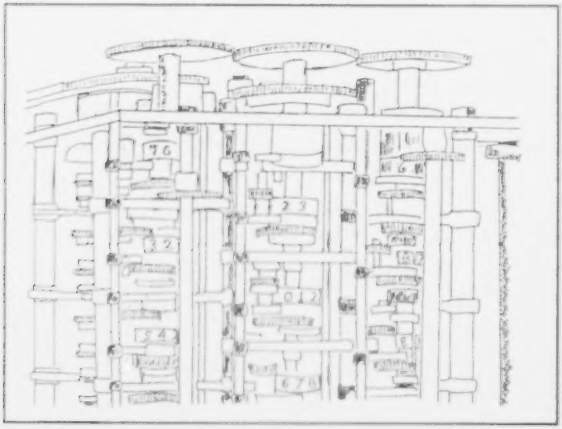
a memory

Four–it had a memory. Again, this was a complex maze of mechanical parts.

an output

Five–it had an output mechamism. A printer!

His first attempt was powered by a hand crank. For the never-completed model he planned to use steam engine power.



listening to history

Even though the analytical engine was never finished, the next time you sit down in front of a sleek home computer perhaps you will be able to hear for one fleeting moment the steam hissing away as Babbage's noble dream faded in his lifetime–and was reincarnated in yours. In modern dress.

first electric power station

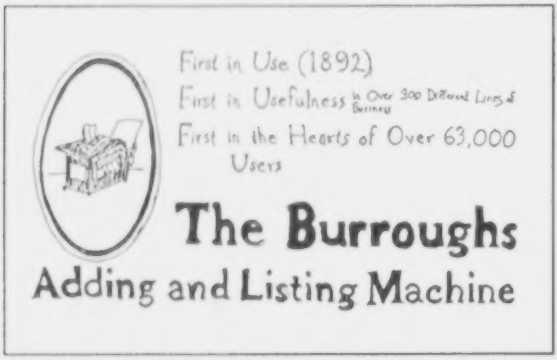
Charles Babbage died in 1871. Eleven years later Thomas Edison pioneered the first commercial electric power station in New York City. It was the coming into the world of this new current electricity that made modern computers possible. In two senses. Electricity for power and for control.

Dorr Felt's macaroni box

Progress continued. In 1887 Dorr Felt of Chicago put together a wooden macaroni box, some meat skewers and rubber bands to make what he called a comptometer, the world's first key-driven calculating machine.

William Burroughs

William Burroughs patented the first commercially successful adding machine in 1892.



competition for census

The next major step came in response to a contest. The data from the U.S. census in 1880 had taken over seven years to count and record. Officials knew they needed a better system for the 1890 census. They sponsored a competition to find one. Three finalists were chosen and given a final test in St. Louis.

punched card system wins

A colored card system took fifty five hours to tabulate the test data. A token system took forty four hours. The winning entry was the world's first punched-card, electrically-driven data processor that took only five and one-half hours to tabulate the data.

Herman Hollerith and IBM

This new winning data processor was invented by a man named Herman Hollerith, who also founded the company that later became the International Business Machines Corporation, IBM. It was used exclusively in the 1890 census and counted

and tabulated all 62,622,250 people in less than six weeks. (In 1880 it took seven years!)

improvements made

Improvements were made over the next decades in the Hollerith punched card system, in the Burroughs and other mechanical calculators but the most important improvements came in a different field–fundamental mathematics.

George Boole

One man, in particular, George Boole, deserves more credit than he has popularly received for laying the early foundations. Though he came from a poor family and never earned a university degree, Boole did manage to become a professor of mathematics and logic at the University of Cork in Ireland. Here, in the late nineteenth century, he laid the foundations for a new algebra of logic, now called Boolean algebra. This was a critical first step in converting the logic of words and sentences into a numerical form that could later be handled by electronic computers.

logic and mathematics

Around 1910 two English philosophers, Bertrand Russell and Alfred North Whitehead, advanced this same effort with a classic work, *Principia Mathematica*. Logic and mathematics were now united, and the way was cleared for giant steps forward in artificial intelligence.

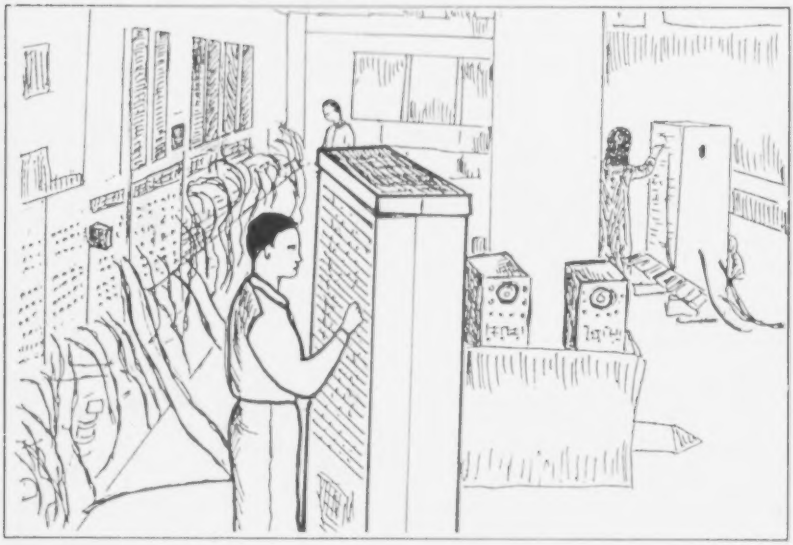
Electricity, logic, mathematics, mechanical invention. All these began to come together just before the Second World War. Under the spur of that war, the first genuine electronic computers were born.

ENIAC

The honor of being the first goes to the breaker of the German war code, COLOSSUS. A close second was a giant computer called ENIAC. ENIAC was designed and built for the U.S. Army to calculate bomb and shell trajectories. It used over eighteen thousand vacuum tubes, took up a large room and used enough electricity to supply a small city.

first general purpose computer

COLLOSUS was built to do just one job, to break the code. ENIAC could be, and was (with some difficulty) programmed to do other things besides calculate bomb and shell trajectories. Thus ENIAC could be called the first general-purpose electronic computer.



UNIVAC

At that time, and for over a decade after the war ended, computers were patterned after the ENIAC. One called UNIVAC was the first commercially successful system. More than fifty of these machines were built and sold. One innovation in UNIVAC was the use of magnetic tape for the input.

expensive machines

At that time, and for over a decade after the war ended, computers were seen as very expensive, very large and very energy wasteful machines. The conventional wisdom said that computers would never be used much except by governments or very large businesses. By people who could afford the millions of dollars in cost–both original cost and care-and-feeding maintenance.

changed with the transistor

All that changed when a new invention called the transistor came along. The transistor was invented by three men at Bell Labs in New Jersey, John Bardeen, Walter Brattain and William Shockley. It turned out to be one of the most important inventions of the twentieth century. In 1956 the three scientists won the Nobel Prize for their work. Almost overnight the transistor made vacuum tubes obsolete and opened the road to the explosion of the inexpensive powerful computers of our day.

vacuum tubes become obsolete

Like a vacuum tube, a transistor could act as an electronic valve. It could be off or on. This meant it could act as the physical chunk that could represent an abstract number. Unlike a vacuum tube, a transistor used very little power, was very small in size and could be easily made in mass production quantities at very low cost.

the silicon chip

No sooner had the transistor been invented and improved than people found ways to reduce its size and to increase its power and versatility. Engineers could design the electronic circuits they wanted, reduce them to microscopic size and print them on a chip of silicon, one of the world's cheapest chemicals, made from common sand! And so we got the marvelous magical silicon chip, the central heart and brain of all modern computers.

changes in size and power

To give you a rough idea of the increase in power that went along with the decrease in size, let's conclude this history by tracing the big changes in power and size over the years.

millions of switches

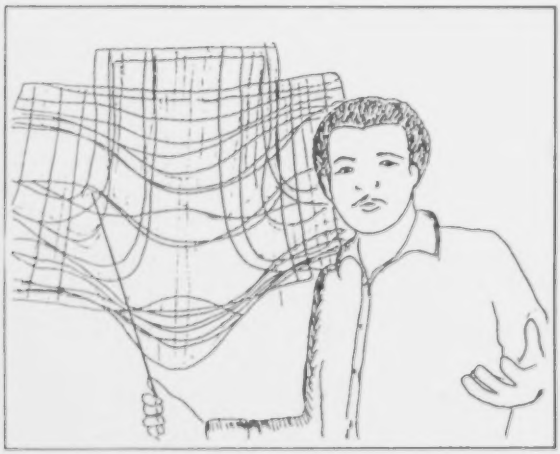
One of the modern logic chips contains millions of switching units. All in a chip that would fit easily on your fingertip. If you had to make this same switching power using vacuum tubes of the ENIAC design (only forty years ago, remember) you would need a space bigger than a football stadium and more power than the city of Chicago uses daily. If you had to make it the way Charles Babbage and Ada Lovelace tried to do, with cogs and wheels and steam engines–there isn't room enough or power enough in this world. And just as important, none of these older methods could ever be reliable enough.

increase in speed

The increase in speed is even more astounding. You can blink your eyes once a second. An electromechanical relay can click back and forth twenty times a second. A vacuum tube can switch thousands of times a second. One of the switches in an electronic chip can switch back and forth, off and on, billions of times a second.

how much is a billion?

Do you realize how much a billion is? If you had a billion dollars and you started to give it away a dollar at a time, and you gave away a dollar every ten seconds, eight hours a day, five days a week, it



would take you well over a thousand years to go broke! Yet that is how many times an electronic switch in a silicon chip can count in one second.

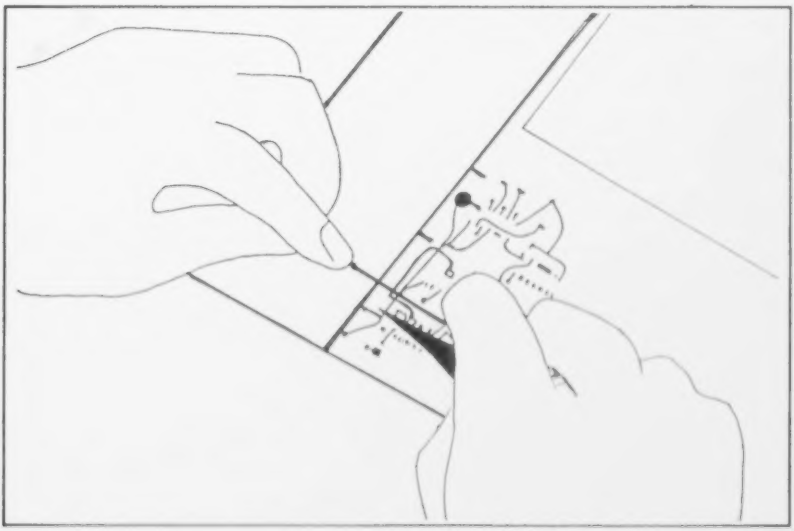
a rival to human brain

And that kind of speed combined with that kind of size makes the modern computer, say some scientists, a rival to the human brain itself. The day of artificial intelligence has arrived.

Or has it?

See Part 2.

Part 2: How a Computer Works



computers and how they work

What is a computer?

How does it work?

Are these magical little machines really intelligent–the way humans are–or are they educated morons, idiot chips with gigantic memories, fabulous calculating speeds and no common sense?

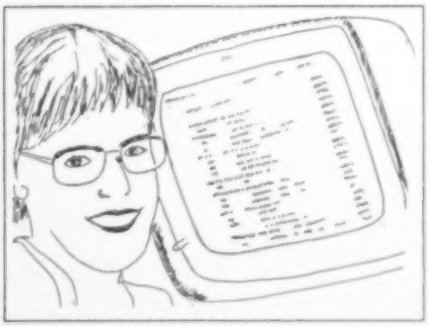
Let's look at these questions and see.

all sizes

Computers come in many sizes and at many prices. At this writing the Cray X-MP is the world's fastest, most powerful computer. Cost: quite a few million dollars. One step down come mainframe computers from companies like IBM which cost two or three million dollars. Then come minicomputers from many manufacturers in the range of tens of thousands of dollars.

personal computers

At the bottom of the pyramid we get the surprising personal computers, sometimes called microcomputers. Apple introduced the first personal computer in 1966. Since then the number, power and speed of these remarkable machines have multiplied many times over. Today most businesses and schools, and many homes make good use of this power and speed.



special-purpose computers

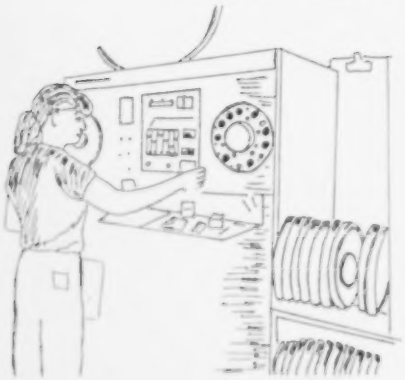
Besides these well-known computers, there are thousands of special-purpose computers built into automobiles, washing machines, dishwashers, VCRs, fax machines, microwave ovens, etc.

all work on same principles

All of these computers, no matter what the size, power or price are full-fledged genuine computers. And they all work on the same general principles.

five basic parts

They all have five basic parts. These five parts are: (1) an input device or devices (in other words, some way of getting information into the computer); (2) a counter or number cruncher, usually called the central microprocessor, the part that does the actual calculating; (3) a controller (some way to make sure the counter does its counting in the right sequence); (4) a memory (usually more than one kind); and (5) an output device or devices (some way of showing or telling the answer).



inputs

So far, so good. It is a little like the human brain in silicon and steel, but only a little like it. For input, for instance, humans have as standard equipment eyes and ears, noses and fingers. The computer's most common way to input is through a typewriterlike keyboard. Some computers can also take information in in other ways. Magnetic tapes, for instance. Photoelectric tubes. Screens that respond to the touch. Microphones, musical instruments, thermometers, pressure-sensitive devices. The list is endless.

processing in the brain

For processing information once it is inside, we have our brain and spinal cord–billions of neurons connected in billions of intricate and mostly unknown ways. These neurons can indeed keep count. They can add, subtract, multiply and divide. They can figure out chess moves, remember dates, balance checkbooks, plan parties and think up experiments and poems.

processing in the computer

All of these things the computer's silicon chips can do also. And it can do most of them faster (much faster) and more accurately (much more accurately) than we can. As for the last three of our human examples–planning parties, thinking up experiments and writing poems–the human brain can do a better job.

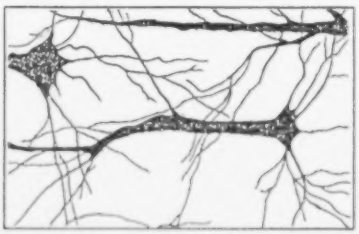
programmed control and software

That is input and processing. For control the human brain (and other animal brains, for that matter) uses some as yet unknown combination of neuron interconnections. The computer also has a control part. The difference is the computer com-

binations of switches and interconnections are not unknown. They have been very thoughtfully programmed that way by the brains of human designers and programmers.This programming is often called the software of a computer, in contrast to the physical hardware you can see and touch.

memory

Now for memory. Human memory is housed in neuron chunks. Human memory is remarkable in its range, in the quantity of information that can be stored and in the incredible richness and speed with which it can be connected and retrieved. On the other hand, human memory is also, as we all know, sadly fallible. The human brain is subject to strange quirks and mysterious lapses. But so long as the power is on, so long as we are alive, memory persists and even dominates our lives.



computer memory: ROM

Computer memory is not quite the same. Most computers have memories stored in at least three different ways. Within the computer itself memories are stored in the form of off/on switches in the silicon chips. Some of the memory elements in the chips are designed and programmed to be permanently off or on. In this way memories are never forgotten, even if the power is turned off. They are also made that way so that operators cannot change them, by mistake or design. These are called ROM chips, meaning "read-only" memories.

computer memory: RAM

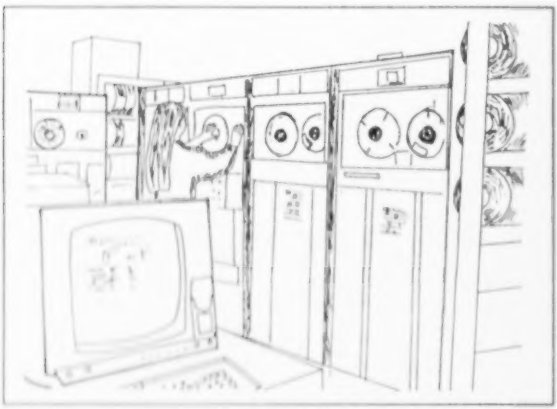
In addition to the ROM chips, inside the computer there is also another group of memory chips that are called the RAM, or "random-access memory" chips. In the RAM chips, too, the memories are stored in off/on elements on the microchips, but unlike the ROM ones, they can be quickly and

easily changed, erased, added to. The memories on RAM chips are lost if the power is turned off.

tapes, disks and more

Both the RAM and the ROM memories are limited in size, though each year computer makers come out with larger memories. For really large amounts of data, however, computers rely on permanent storage in external forms. The most common devices here are magnetic tapes and disks. Personal computers often use floppy disks for memory. For larger memories hard disks are becoming more common.

There are also new methods coming into use now like optical disks, charge-coupled devices and bubble chambers.



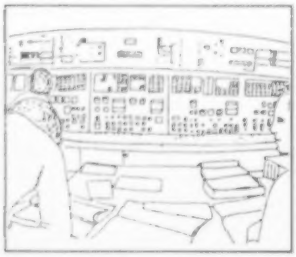
Input, calculation, control and memory. The final essential for a computer is an output.

human outputs

In the case of humans, output is movements of muscles. And what a splendid garden of meanings and events those muscular movements can be. Everything from the touch of a hand to the sound of a song. From driving a car to fixing a heart. From hitting a ball to swimming in a lake. From writing a poem to planning and carrying out an experiment.

computer outputs

In the case of the computer, the output is also rich, though more restricted in form. The two most common kinds of output for the computer are display on a video terminal screen and printing on a piece of paper. Many other outputs are possible and also widely used. Recording on a magnetic disk for example. Or driving a pen, making sounds from a loudspeaker, controlling a robot, turning off a furnace, managing the flow of oil through a refinery or the fission of atoms in a nuclear power plant. And a million more practical applications limited only by the imagination and skill of the humans who design them.



a review

Let's review now. In order, here is how a modern digital computer works. (Note: There are also *analog* computers which are not as common today and work on somewhat different principles.)

input

(1) Information is entered into the computer through one or more input devices. Whatever the source of the information, it must be converted first into digital form. That is, the computer can only work with yes or no, on or off, open or closed.

microprocessor

(2) The computer can now add, subtract and compare these digital bits of information. It does its adding and subtracting and comparing in the microprocessor, a small microchip or group of microchips.

control program

(3) The microprocessor is in turn controlled by a program that is stored on a ROM chip or chips. This program describes for the computer the exact

sequence of steps it must take to work with any of the data you put in.

memory

(4) The microprocessor can draw on information in the memory, either internal (RAM) or external (magnetic tapes or disks) for help in carrying out prescribed sequences.This includes information for control and for processing that is taken from software programs created by the user or provided by outside programmers.

output

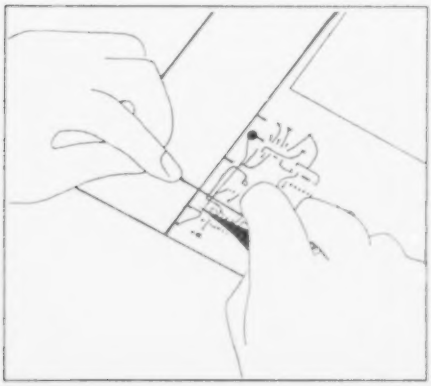
(5) Once it finishes its calculations in the prescribed sequence, the computer sends the results to some kind of output device, usually a video screen or a printer.

the most important part

You have probably noticed in this explanation how often I have mentioned the silicon chips. They are the most important single part in any computer. Let's pause now and look more closely at that single most important part. Some would liken it to the neuron, the basic nerve cell of the human brain.

built of silicon chips

The microprocessor, the controller and most of the memory are built of combinations of different multipurpose silicon chips. In a sense, a silicon chip is itself a computer. The circuits for these chips are designed by the hand and brain of computer engineers. They are then reduced to microscopic dimentions and reproduced (printed) by the millions on small chips the size of your fingernail. On its small square, thousands, often millions of microscopically tiny switches, conden-



sors and other electrical components are connected together in a printed circuit maze of clear logic and faultless reliability.

binary code

Each one of the millions of switches has only two conditions. On or off. Yes or no. Open or closed. This two-choice condition is called a binary system. And it is from the binary code logic of the possible combinations of millions of yeses or nos, ons or offs, openings or closings that the computer gets its strange and wonderful power.

bits and bytes

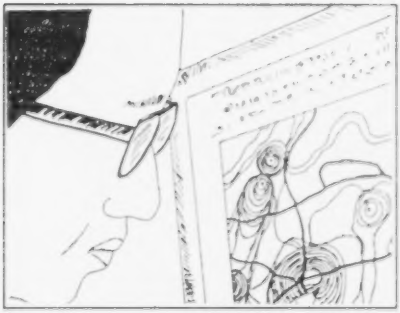
All of the information you want to put into the computer must be converted into *bits*. That is, it must be coded (either by the human programmer, or by circuits already programmed in the computer) into on/off code that a computer can understand. Sometimes you see the word b*yte* also. This means a unit of eight bits of information.

a ROM chip

Some microscopic switches to hold this information are in the control unit of the computer.There will be millions of such on/off switches permanently set to *on* or *off* by the designers of the computer. They are called ROM chips.

RAM chips

Other switches are in the RAM, random-access memory. They are not permanently set. The RAM switches are the ones used for the changeable instruction software and for the actual calculations.



The rapidly increasing power of computers and the rapidly decreasing size and price are all due to rapidly accelerating advances in the design and production of these miracle silicon chips.

outthink its creator

How much further can they go? Will we eventually, and perhaps quite soon, produce a super supercomputer that is truly intelligent? One that can outthink its creator?

yes and no

In some specialized ways the answer is already known. And the answer is yes. Computers have been designed and built and operated to play chess at near master level, good enough to defeat all but the very top players. And these same computers are able to learn by their mistakes.

So too, computers have been designed, built and operated to far surpass any human brain in speed and quantity of information they are able to process. Can you do a billion long division problems a second?

a new kind of Industrial Revolution

All of this replacing of human brain power by machine brain power reminds you a little of the big change in the last century Industrial Revolution, when human and animal muscle power were rapidly replaced by machine power. Some call our times the Second Industrial Revolution as electronics takes over many of the jobs human brain power used to do.

disagreements

And yet, despite their incredible capacity and power, most experts say that computers will never seriously rival the human brain in basic intelligence and creative power. A few would disagree. And the disagreement hinges mostly on what we know or don't know about human intelligence and creativity, rather than on what we predict about the computer's future capacity and power.

the power of human brain?

No one doubts the latter will increase to who knows what fantastic power. But what about the former, the human power? The power of the human brain and mind? Unlike a silicon chip, the human brain or mind (there is much dispute

about whether mind and brain are the same thing, but that is another story) does not seem to process information sequentially in digital bits. Just how it does do it, we don't yet know.

better than a computer

However it does it, the human brain (or mind) does manage some tricks that thus far the computer brain can't seem to get the foggiest notion how to do.

The mind easily recognizes faces. The computer has great great difficulty doing this.

The human mind laughs at jokes. The computer is solemn as a stone (or a silicon chip).

The human mind (mostly) has a generous store of common sense. The computer has no common sense.

The human mind can ...

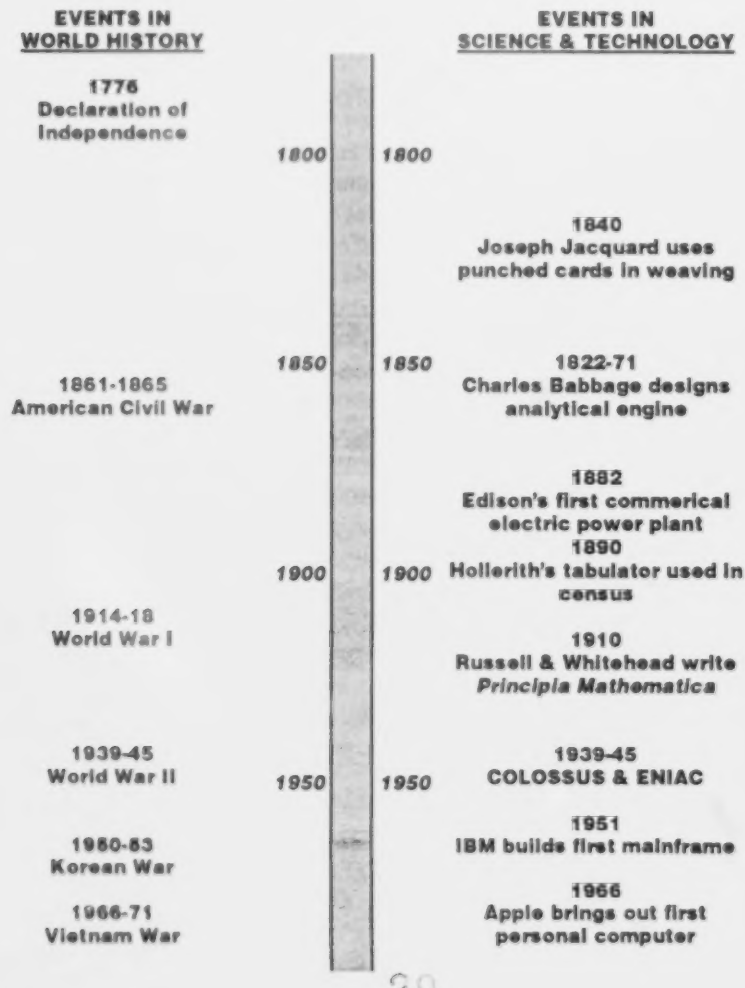
"see the world
in a grain of sand,
heaven in a wild flower,
hold infinity
in the palm of its hand,
and eternity
in an hour." *

The computer would be baffled.

*William Blake

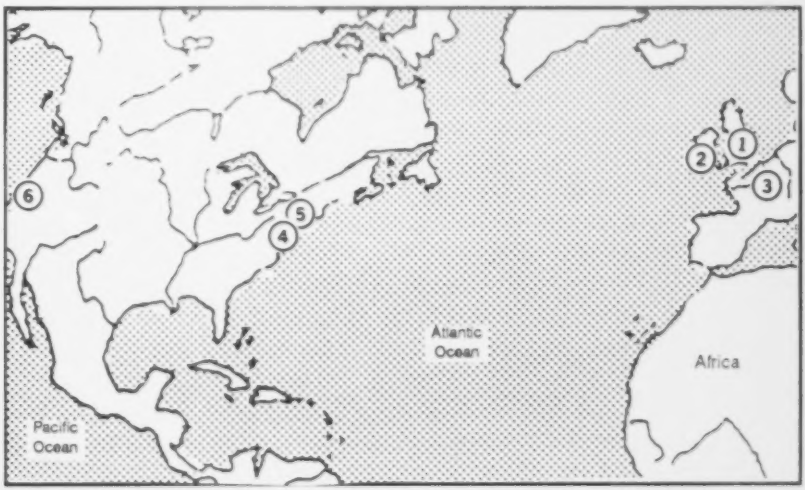
TIME ...

To understand the world of today it helps to know something about the world of yesterday. Kings and queens, wars and famines, presidents and paupers have all played a part. But more important than any of these in changing the past world into the world of today has been science and technology. The time line below will help you place important events and people in historical time.



SPACE ...

There is a saying, "If you don't know where you are going, any road will get you there." One of the important parts of knowing where you are going is a knowledge of geography. The map below will help you to locate the important events and people discussed in this book.



1. England — Where much of the early work on computers was done. Turing, Babbage, Russell and Whitehead all lived and worked here.

2. Cork, Ireland — Where George Boole was professor of mathematics and invented Boolean algebra.

3. Paris, France — Where Pascal and Jacquard lived and worked.

4. New Jersey — Headquarters of Bell Labs, one of the pioneers in electronics technology.

5. Yorktown, New York — Headquarters of IBM research. Leading computer company.

6. Silicon Valley, California — Headquarters for many high-tech computer firms, including Apple.

SPIRIT ...

Time and space are meaningless without spirit. Spirit is the part in each of us that understands. The part that sees connections between words and things–connections that surprise and make sense. Study the key words, concepts and ideas below so that you can understand how time, space and spirit worked in the past–and are working today.

abacus — An instrument of ancient origin used for calculating. Made of beads strung on rods. (p. 2-4)

artificial intelligence — A theory of some computer designers that envisions making a computer which mimics human intelligence. (p. 2, 21-23)

Babbage, Charles — An English engineer (1792-1881) who designed an "analytical machine" that is often considered the world's first true computer design. (p. 5-7, 12)

binary — Having only two choices. Yes or no. On or off. Most computers use this system. (p. 21)

bit — A single unit of information. On or off. (p. 21)

Boolean algebra — A form of mathematics which converts logical statements to symbols and numbers. Named after its inventor, George Boole. (p. 9)

byte — A unit of information in computers, usually meaning a group of eight bits. (p. 21)

electromagnetic relay — A switch that turns on or off depending on the current through a magnet. Used in early computers and telephone systems (p. 4, 12)

electronics — The science of managing electrons for use in computers, television, radio, etc.

ENIAC — One of the first large computers. Built by the U.S. Army in World War II to calculate shell trajectories. (p. 9-10, 12)

floppy disk — A magnetic disk used for permanent memory storage in personal computers. (p. 18)

hard disk — A sealed magnetic disk used for permanent memory storage. Has much larger capacity than a floppy disk. (p. 18)

IBM — International Business Machines, one of the world's largest computer companies. (p. 8)

logic — A branch of philosophy that studies how we think. Symbolic logic relates thinking principles to mathematics and makes programming modern computers possible. (p. 9)

Lovelace, Ada — Considered the world's first computer programmer. Worked with Charles Babbage to program his analytical machine. A daughter of the poet, Lord Byron. (p. 5-7, 12)

memory — In computers there are many ways to remember data. Floppy disks, hard disks, RAM chips, ROM chips, etc. (p. 15-18, 20-21)

microchip — A small wafer, mostly silicon, on which a circuit is printed containing many thousands of electronic switches and wires. The basic unit of which computers are made. (p. 11, 19-23)

microprocessor — The part of the computer that does the actual calculating. (p. 15, 19)

neuron — A cell that specializes in carrying messages. In the brain, neurons are the basic unit. (p. 16)

Pascal, Blaise — A French scientist and mathematician (1623-62) who is given credit for building one of the world's first mechanical calculators. (p. 4-5)

program — The combination of coded instructions that tells a computer what operations to perform and in what order. (p. 5-7, 16-17, 19-20)

programmer — The person who makes up the program for a computer. (p. 6-7, 17)

RAM — Random-Access Memory. RAM chips store numbers in the computer temporarily while the computer is up and running. Once the computer is turned off, RAM chips forget. (p. 17-21)

ROM — Read-Only Memory. ROM chips store numbers that make up important programs in the computer. They are not changed by operators. Information is not lost from ROM chips when computer is turned off. (p. 17-21)

Russell, Bertrand — An English philosopher and mathematician (1872-1970) who, along with Alfred North Whitehead, made important advances in symbolic logic and mathematics. (p. 9)

silicon chip — See microchip.

transistor — An electronic device made of semi-conducting ceramics that switches on or off and is a basic element of modern computers. (p. 4, 11-12)

Turing, Alan — An English mathematician and engineer who led the team that built one of the first modern electronic computers in World War II. (p. 1-2)

Whitehead, Alfred North — An English philosopher who, along with Bertrand Russell, advanced symbolic logic and mathematics. (p. 9)

In addition to the above, *The Computer* also teaches about other important people, places, things, and ideas. Often you can figure out the meaning of a new term by seeing how it is used in context. Make sure you know the meaning of the following words. For help, check the pages listed in this Learning Power Book, or if necessary, a dictionary or encyclopedia:

analog computer (p. 19); **Bardeen, John** (p. 11); **Bell Lab** (p. 11); **Boole, George** (p. 9); **Brattain, Walter** (p. 11); **Burroughs, William** (p. 8); **calculator** (p. 2-5); **census** (p. 8); **China** (p.2); **Cray supercomputer** (p. 14); **digital** (p. 19); **Edison, Thomas** (p. 7); **Felt, Dorr** (p. 8); **Hollerith, Herman** (p. 8); **Industrial Revolution** (p. 22); **Jacquard, Joseph** (p. 6); **mainframe** (p.14); ***Principia Mathematica*** (p. 9); **printed circuits** (p. 20); **Shockley, William** (p. 11); **software** (p. 17, 25); **UNIVAC** (p. 10); **vacuum tubes** (p. 4, 9-12).

STUDY SUGGESTIONS ...

1. The history of computer development is not well known today. The early pioneers like Charles Babbage, Dorr Felt, Herman Hollerith and Alan Turing have never become famous names. Individually and as a group they make fascinating subjects to read about, however. Do so.

2. This book (page 12-13) gives one way to visualize large numbers. Invent other ways of doing so and share with classmates and teacher.

3. In many countries of the world, including the Soviet Union, abacuses are far more common than cash registers or electronic calculators in shops and stores. Get an abacus and learn to use it. Compare its operation with that of a modern calculator or computer.

4. For insights into how a large computer is designed, read and report on the book *The Soul of a New Machine* by Tracy Kidder.

5. This book claims that computers do not have a sense of humor. However, computers have been programmed to write poems, plays and stories. Sometimes the results are hilarious. See if you can program a personal computer to write a poem or a play or make up a joke.

6. Recently a computer was able to defeat some grand masters in chess. It may not be long before it can defeat world champions routinely. Does this prove computers are intelligent? Discuss and debate.

7. Both Bell Laboratories and IBM have active public relations departments that will be glad to send you information about computers as well as other telecommunication subjects. Write to: Bell Labs, Mountain Ave., Murray Hill, NJ 07974. IBM, Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598.

8. It is a commonplace statement nowadays that computers are changing the world. Follow through a typical day in your own life. List every way in which computers played an important part directly or behind the scenes (bank, telephone, etc.).

9. How would your world and your typical day be different if there were no modern computers?

Bibliography ...

Bernstein, Jeremy. *The Analytical Engine: Computers, Past, Present and Future.* New York: William Morrow, 1981.

Brennan, Jean Ford. *The IBM Watson Laboratory at Columbia University: A History.* Armonk, NY: IBM, 1971.

Evans, Christopher. *The Making of the Micro: A History of the Computer.* New York: Van Nostrand Reinhold, 1981.

Feigenbaum, Edward, and Pamela McCorduck. *The Fifth Generation: Artificial Intelligence, Japan's Computer Challenge to the World.* Reading, MA: Addison-Wesley, 1983.

Gilder, George. *Microcosmos: Into the Quantum Era of Economics.* New York: Simon & Schuster, 1989.

Goldstine, H. *The Computer from Pascal to Von Neumann.* Princeton, NJ: Princeton University Press, 1972.

Kidder, Tracy. *The Soul of a New Machine.* Boston, MA: Little Brown, 1981.

Langone, John. *Superconductivity, The New Alchemy.* New York: Contemporary Books, 1989.

Lathrop, Ann, and Bobby Goodson. *Courseware in the Classroom–Selecting, Organizing and Using Educational Software* New York: Addison-Wesley, 1983.

Maben, Prescott C. *Mission Communication: The Story of Bell Laboratories.* Murray Hill, NJ: Bell Labs, 1976.

McCorduck, Pamela. *Machines Who Think.* San Francisco: W. H. Freeman, 1979.

Park, Gordon. *Micro-Man, Computers and the Evolution of Consciousness.* New York: Macmillan, 1982.

Renmore, C. D. *Silicon Chips and You.* New York: Beaufort Books, 1980.

Turing, S. *Alan M. Turing.* Cambridge: W. Heffer & Sons, 1959.

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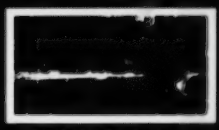

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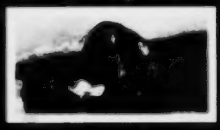

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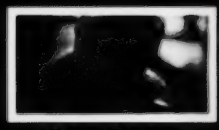

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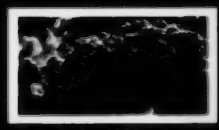

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